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MATHEMATICS.—*Account of researches in the algebra of physics.*[1] I. A. MACFARLANE.

As these researches extend over thirty years and the results have appeared in a variety of publications, I am glad to accept the invitation of the Philosophical Society to give a connected account of the principal results, more especially because I have reason to believe that I have solved the main difficulties of the problem investigated.

Note on plane algebra. Proc. Roy. Soc. Edinb., 1883, pp. 184–186. I began by studying plane algebra as a logical generalisation of ordinary algebra. The algebraic symbol used was a small Roman letter, which denoted a length combined with an angle: thus $\mathrm{a} = a \,.\, \alpha \quad \mathrm{b} = b \,.\, \beta \quad \mathrm{c} = c \,.\, \gamma \quad \mathrm{r} = r \,.\, \theta$. In this notation $\sqrt{-1}\, r = r \,.\, \pi/2$ and $-r = r \,.\, \pi$. The sum was obtained by the parallelogram construction. The product ab was defined as the product of the lengths combined with the sum of the angles; that is $\mathrm{ab} = ab \,.\, \alpha + \beta$, giving $\mathrm{b}^2 = b^2 \,.\, 2\beta$. The quotient $\frac{1}{\mathrm{a}}\mathrm{b}$ was defined as the quotient of the lengths combined with the difference of the angles; thus

$$\frac{1}{\mathrm{a}}\mathrm{b} = \frac{b}{a} \cdot -\alpha + \beta; \text{ giving } \frac{1}{\mathrm{b}}\mathrm{b} = 1 \cdot 0$$

The product of three quantities $\mathrm{abc} = abc \,.\, \alpha + \beta + \gamma$, giving

[1] Read before the Philosophical Society of Washington, April 20, 1912.

$b^3 = b^3 \,.\, 3\beta$ and generally $b^n = b^n \,.\, n\beta$. Again since db = d $(b \,.\, \beta) = db \,.\, \beta + bd\beta \,.\, \beta + \pi/2$ it follows that $db^2 = 2bdb$, and generally $db^n = nb^{n-1}$ db. Also d(ab) = adb + bda. As the fundamental properties of the symbol are the same in form as those of the ordinary algebraic symbol, I concluded that the theorems of line algebra remained true generally without change of form in plane algebra. The principle was applied to produce problems in series for examination papers, and some were propounded in the columns of the *Educational Times* (*e.g.*, Reprint, **45**: 28). I asked Professor Tait what he thought of the principle; to which he replied that it was a pretty bold step to take. But if we take conjugate powers and products, no such easy generalisation is possible. The conjugate product of a and b has the product of the lengths, but the difference of the angles, $ab \,.\, -\alpha + \beta$, giving for the conjugate square bb $= b^2 \,.\, 0$. Also the conjugate of abc $= abc \,.\, \alpha - \beta + \gamma$ giving bbb $= b^3 \,.\, \beta$. It was from this point of vantage that I began to study the space-generalisation of algebra.

Physical arithmetic. Macmillan and Company, 1885. The original title of this book was *Arithmetic of Physics.* In it I attempted a thoro-going application of the following principle, enunciated by Maxwell (*Heat*, p. 75).

> Every quantity is expressed by a phrase consisting of two components, one of these being the name of a number, and the other the name of a thing of the same kind as the quantity to be expressed, but of a certain magnitude agreed on among men as a standard or unit.

In the book each quantity is analysed into unit, numerical value, and where necessary, descriptive phrase. This descriptive phrase often has reference to the direction of a line unit. A compound unit is expressed in terms of its elementary units by means of "by" and "per." Originally all the reasoning in working out examples was done by means of the expression for the complex unit involved; at the suggestion of Professor Tait I introduced an equivalence method, which I do not now think is an improvement. Equivalences are treacherous, especially in space-analysis. The above analysis afterwards led to the idea of analysing each space quantity into modulus and vector-unit, simple or compound.

Principles of the algebra of physics. Proc. Amer. Assoc. Adv. of Science, **40**: 65–117. I thus enunciated the problem as it appeared to me then (p. 65):

> I am convinced that the notation of quaternions can be improved; that the principles require to be corrected and extended; that there is a more complete algebra which unifies quaternions, Grassmann's method, and determinants, and applies to physical quantities in space. The guiding idea in this paper is generalization. What is sought for is an algebra which will apply directly to physical quantities, will include and unify the several branches of analysis, and when specialised will become ordinary algebra.

The fundamental rules of quaternions were investigated by considering (1) the product of two quadrantal versors, (2) the product of a quadrantal versor and a unit vector, (3) the product of two unit-vectors.

Let h, j, k (fig. 1) be a righthanded system of orthogonal axes, and let $h^{\pi/2}$ denote a quadrant round h. Then if we take the quadrants in the cyclical order

$$h^{\pi/2}\, j^{\pi/2} = k^{\pi+\pi/2}$$

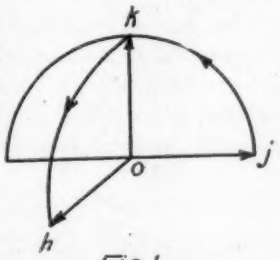

Fig 1.

Why do we take the angle greater than π, not the smaller angle? Because the equivalent rotation round k which will bring j into coincidence with h must be righthanded, and therefore amounts to $3\pi/2$. But when we take the anti-cyclic order, we get

$$j^{\pi/2}\, h^{\pi/2} = k^{\pi/2}$$

The rules are thus expressed in tabulated form

	$h^{\pi/2}$	$j^{\pi/2}$	$k^{\pi/2}$
$h^{\pi/2}$	h^{π}	$k^{3\pi/2}$	$j^{\pi/2}$
$j^{\pi/2}$	$k^{\pi/2}$	j^{π}	$h^{3\pi/2}$
$k^{\pi/2}$	$j^{3\pi/2}$	$h^{\pi/2}$	k^{π}

Consider next the product of a quadrantal versor and a unit-vector. From the diagram it is evident that $h^{\pi/2} j = k$ but $j^{\pi/2} h = -k$; also $h^{\pi/2} h = h$. Hence we have the table:

	h	j	k
$h^{\pi/2}$	h	k	$-j$
$j^{\pi/2}$	$-k$	j	h
$k^{\pi/2}$	j	$-h$	k

Consider finally the product of two unit-vectors. From considerations of projection I derived the table

	h	j	k
h	$+$	k	$-j$
j	$-k$	$+$	h
k	j	$-h$	$+$

This table is implicitly assumed by vector-analysts; but there is an evident difficulty in reconciling it with the principle of dimensions and in harmonizing it with the products of quadrants, which are in a sense imaginary unit vectors. To overcome the former difficulty I adopted the following theory (p. 79):

> In such an expression as xi it is more philosophical and correct to consider the x as embodying the unit, while i denotes simply the axis. I look upon the magnitude as containing the physical unit, to be arithmetical ratio and unit combined, and different vectors have different physical units. An axis is not a physical quantity but merely a direction.

In pursuance of this theory I considered the types of compound

axes of the first four orders. These are given in the first place by the homogeneous products:

α	$\dot{\alpha}^2$	α^3	α^4
	$\alpha\beta$	$\alpha^2\beta$	$\alpha^3\beta$
		$\alpha\beta^2$	$\alpha^2\beta^2$
		$\alpha\beta\gamma$	$\alpha^2\beta\gamma$
			$\alpha\beta^3$
			$\alpha\beta^2\gamma$
			$\alpha\beta\gamma^2$
			$\alpha\beta\gamma\delta$

and in the second place by inserting the conjugate forms. At that time I supposed these expressions to denote compound axes and the elements to be orthogonal. It was only after much subsequent study that I discovered the true nature of these expressions as compound units.

In connection with this I used a *pole* notation; $\overline{\alpha\beta}$ was used to denote the axis which is perpendicular to α and to β, or with greater truth the conjugate axis of their plane. As the vinculum is inconvenient to print, it is better to use a special form of bracket as $[\alpha\beta]$. This notation expresses unambiguously any complex pole, such as $[[\alpha\beta]\gamma]$ or $[[\alpha\beta]\,[\gamma\delta]]$.

A quaternion was defined, not as the ratio of two vectors simply, but as the ratio of two vectors when they are free to rotate in their own plane. The former definition—the ratio of two vectors—was held to be the true definition of Gibb's dyad. A quaternion was analysed into tensor, axis, and amount of angle, and the relation of these elements was expressed, for example, by

$$q_1 = a_0\,\alpha^a \qquad q_2 = b_0\,\beta^b$$

The axis was supposed to be defined by two elements, and in contrast to Hamilton (Elem. Bk. II, Art. 130) the angle was not restricted to being less than π, but on the contrary might have any magnitude.

As a consequence the square of a quaternion was defined by $q^2 = a_0{}^2\alpha^{2a}$, which Hamilton could not logically do, because if a were greater than $\pi/2$, then $2a$ would be impossible. Similarly the square-root was defined *definitely* by

$$q^{\frac{1}{2}} = \sqrt{a_0}\,.\,\alpha^{a/2}$$

It was shown that a quaternion could be reduced to the sum of two homogeneous components, by writing

$$a_0\alpha^a = a_0 \quad \{\cos a \,.\, \alpha^0 + \sin a \,.\, \alpha^{\pi/2}\};$$

and it was pointed out that the righthand member was not a full equivalent of the lefthand member, as all the complete turns had been dropped.

It was shown that the fundamental principle in the composition of quaternions is

$$\beta^{\pi/2}\,\gamma^{\pi/2} = -\cos\beta\gamma - \sin\beta\gamma\,[\beta\gamma]^{\pi/2} = [\beta\gamma]^{\pi+<\beta\gamma}$$

This principle makes both terms negative, in contrast to the Hamiltonian principle which makes the latter term positive, in order apparently that the angle may be less than π. When both terms are negative, it is much easier to pass to the analogous principle for unit vectors. The principle is proved as follows:

Choose the standard case where the angle between the planes is less than $\pi/2$ (fig. 2). The order from β to γ (by short way) together with the righthanded screw determine the pole $[\beta\gamma|$. Then $\beta^{\pi/2}\,\gamma^{\pi/2}$ is the resultant of the quadrants AB and BC. The positive angle round OB which will take OA into the position OC is not the angle which takes the shortest way but the angle which is determined by the screw rule, namely $\pi + <\beta\gamma$: hence

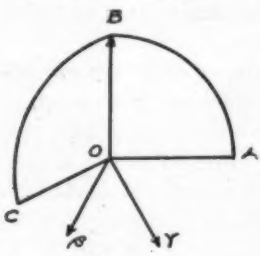

Fig. 2.

$$\beta^{\pi/2}\,\gamma^{\pi/2} = -\cos\beta\gamma - \sin\beta\gamma\,[\beta\gamma]^{\pi/2}$$

According to Gibbs the dyad AL is a kind of symbolic product in which A is the antecedent and L the consequent. I pointed out that according to the use which he makes of the dyad, it is not a product but a quotient, and expresses the ratio of the consequent to the antecedent. And in the expression for ∇ it seemed plain that to express a rate, $d_x u\,\frac{1}{dxh}$ or $\frac{du}{dx}\,\frac{1}{h}$ was more correct than $\frac{du}{dx}\,h$.

In the proof which was given that $\beta^b = e^{b\beta^{\pi/2}}$, a method was introduced which afterwards proved effective in demonstrating the Exponential Theorem. It consists in restoring the original powers from which a reduced expression was derived:

$$\begin{aligned}\beta^b &= \cos b \cdot \beta^0 + \sin b \cdot \beta^{\pi/2} \\ &= \left\{1 - \frac{b^2}{2!} + \frac{b^4}{4!} - \right\}\beta^0 \\ &+ \left\{b - \frac{b^3}{3!} + \frac{b^5}{5!} - \right\}\beta^{\pi/2} \\ &= 1 + b\beta^{\pi/2} + \frac{b^2}{2!}\beta^{\pi} + \frac{b^3}{3!}\beta^{3\pi/2} + \frac{b^4}{4!}\beta^{2\pi} + \\ &= e^{b\beta^{\pi/2}}\end{aligned}$$

PHYSICS.—*The melting points of fire bricks.* C. W. KANOLT. Communicated by C. W. Waidner. To appear in the Bulletin of the Bureau of Standards.

We are accustomed to thinking of a melting point as a temperature at which a substance changes from a rigid to a fluid condition, but a melting point can be precisely and rationally defined only as the temperature at which a crystalline or anisotropic phase and an amorphous or isotropic phase of the same composition can exist in contact in equilibrium. While this definition is satisfactory for pure substances, so complex a mixture as an ordinary fire brick usually has no single definite melting point according to this definition, since several anisotropic phases may be present, all differing in composition from the isotropic phase produced by fusion. We can then only select the temperature at which the transition from a rigid to a fluid state seems most distinct, and can call this the melting point only by apology. In the case of fire bricks, the transition temperatures so found are fortunately sufficiently distinct. I have taken as the melting point the lowest temperature at which a small piece of the brick could be distinctly seen to flow.

The experiments were conducted in an Arsem graphite resistance vacuum furnace. The samples were usually inclosed in a refractory tube made of a mixture of kaolin and alumina in the

proportions to form sillimanite, to protect them from the small amount of reducing gas in the furnace, altho the action of this gas was slight. The samples were observed thru a glass window in the top of the furnace.

The temperatures were determined by means of a Morse optical pyrometer of the Holborn-Kurlbaum type, which was sighted vertically downward thru the glass window. The carbon-filament pyrometer lamp was calibrated by two methods. In the first calibration it was sighted into a platinum resistance furnace in which black-body conditions were obtained, and the temperature of which was measured by platinum platinum-rhodium thermocouples. These thermocouples had been calibrated against the freezing points of pure metals. In the second calibration the lamp was calibrated against the freezing points of metals directly, without the intermediation of thermocouples. The metals used were copper, silver and the copper-silver eutectic, which freeze at 1083°, 961°, and 779° respectively. The metals were melted in the vacuum furnace in graphite crucibles, the pyrometer being sighted into a thin-walled graphite tube inserted in the metal. The pyrometer readings corresponding to the freezing points were determined by means of cooling curves. With silver and copper, heating curves were also obtained.

As the melting points to be measured were above the working limit of the pyrometer lamp, an absorption glass was interposed between the pyrometer and the furnace.

The true temperatures were then found from the apparent temperatures measured thru the glass, by means of the equation

$$\frac{1}{T_2} - \frac{1}{T_1} = A$$

where T_1 is the absolute temperature of the furnace, T_2 is the apparent temperature observed thru the glass, and A is a constant. The value of A was determined by calibrations at various temperatures. A small correction was also applied for the absorption and reflection of the glass window of the furnace.

The samples, which were from 1 to 2 cm. in diameter, were heated at the rate of about 10° per minute when near the melting

point. It was found that in the case of certain bricks made of heterogeneous material of relatively low melting point, the melting points were slightly higher after six hours heating to 1550°, apparently as the result of the gradual running together of dissimilar particles to form a mixture having a higher melting point than the most fusible of the original materials.

The results are summarized in the following table:

MELTING POINTS OF FIRE BRICKS

MATERIAL	NUMBER OF SAMPLES	MELTING POINT CENTIGRADE
Fire clay brick	41	1555 to 1725 mean 1649
Bauxite brick	8	1565 to 1785
Silica brick	3	1700 to 1705
Chromite brick	1	2050
Magnesia brick	1	2165
Kaolin	3	1735 to 1740
Bauxite	1	1820
Bauxite clay	1	1795
Chromite	1	2180
Pure alumina		2010
Pure silica		1750

The value 1750° given for silica is not the true melting point, but represents approximately the temperature at which the silica flows distinctly. It was found that silicon carbide does not melt below 2700°; it becomes unstable at much lower temperatures.

CHEMISTRY.—*Notes on chemical stability.* F. W. CLARKE, Geological Survey.

The term chemical stability is one of those qualitative expressions which convey a definite idea to the mind, even tho they cannot be formulated quantitatively. One substance is easily formed and difficultly decomposable; it is therefore said to be stable. Another is made with much trouble and decomposes readily, and is described as unstable. The distinction is clear, but the conditions of formation and decomposition are due to various agencies which may reinforce or oppose one another.

Molecular saturation, molecular symmetry and simplicity of constitution are favorable to stability; unsaturated compounds or highly complex substances are less likely to be permanent. Stability is also a function of temperture, for one compound may decompose below 100°, while another can be heated to 2000° without breaking down. At the absolute zero all compounds should be equally stable. Furthermore, stability is conditioned by association or environment. Two substances, each stable by itself, may form, when brought together, an unstable system. That is, they react chemically, to generate a new system of greater stability. Here again, temperature is a controlling factor, and pressure also may exert an influence. At very low temperatures, chemical activity ceases, and at very high temperatures all compounds are dissociated. Each reaction is possible only within its own range of temperature, which may be low or high. At ordinary temperatures sodium sulfate and silica can remain in contact indefinitely; at a full red-heat they react, the sulfate is decomposed and a silicate is formed. Stability, then, is a purely relative term, and must always be considered with reference to specific conditions. A substance which is stable under one set of conditions becomes unstable under another.

The foregoing observations are obvious and commonplace, but they serve as a preface to something which is less evident and which seems to have received little attention so far. When two elements unite in equal or nearly equal masses, the compound produced is more likely to be stable than when the masses widely diverge. For example, sulfur dioxide, in which the masses of sulfur and oxygen are practically the same, is more stable than the trioxide. When the latter compound is decomposed by heat the dioxide is one of its products, and when sulfur burns in air, the dioxide alone is formed. In carbon monoxide the elements are combined in the ratio 12 to 16; and this substance, despite the fact that it is unsaturated, is more stable than the dioxide with the ratio 12 to 32. Among the oxides of nitrogen the same relation holds, and the compound NO, with the simplest ratio between the masses, is the most stable of all. Other good examples are furnished by cyanogen, 12 to 14, boron nitride, 11

to 14, and sulfur monochloride, 32 to 35.5. Sulfur tetrachloride, 32 to 142, is very unstable. In short, stable equilibrium seems to be most easily established when the combining masses approach equality; even though the rule may be modified or apparently abrogated in some cases by other conditions. Such conditions are sufficiently indicated in my prefatory remarks.

The influence of what, for want of a better name, may be termed mass equilibrium, can be illustrated in many ways. Consider, for example, the several series of normal hydrides; in each series the lowest member is the most stable. Hydrogen combines with fluorine in the cold, and forms a stable compound. With chlorine the product is also stable, but formed less energetically. Hydrobromic acid is not so stable, and hydriodic acid, which can only be prepared by indirect methods, decomposes with great ease. The same rule holds for the series from NH_3 to SbH_3, and the series H_2O to H_2Te, with a stable member at one end, and an unstable one at the other. Even the hydrides of the alkaline metals show a similar relation; that of lithium, with the smallest ratio between its components being the most stable. In methane, with the ratio 4 to 12 or 1 to 3 we have a very stable compound, perhaps the most stable or least reactive, chemically, of all the normal hydrides. Among the alkaline oxides that of lithium, ratio 14 to 16, is the one most easily prepared and preserved. Examples like these might be multiplied almost indefinitely; provided that the comparisons are made between similar compounds in strictly definite series. When different series are compared other influences may come into play and modify the mass relations.

A study of solubilities also reveals some regularities which seem to indicate mass relations like those already considered. In many series of compounds the solubility is least when the combined masses most nearly approach equality. The alkaline chlorides and iodides, for instance, show this regularity clearly, as follows: The solubilities represent grams of salt in 100 grams of water at 0°.

COMPOUND	SOLUBILITY	ATOMIC WEIGHT DIFFERENCE
LiCl	63.7	28.5
NaCl	35.6	12.5
KCl	*28.5*	*3.6*
RbCl	77.0	50.0
CsCl	161.4	97.3
LiI	152.0	120.0
NaI	159.0	104.0
KI	126.1	87.9
RbI	137.5	41.5
CsI	*38.3*	*5.8*

The bromide series is less complete and is inconclusive. Rubidium bromide should be the least soluble, but the existing data give this place to the potassium salt. The series needs further investigation. As for the fluorides, the slight solubility of the lithium and sodium salts is well known, and emphasizes the present argument. To the nitrates of the alkalies the rule seems not to apply; but in the sulfates, if we compare the metals with the radicle SO_4, the regularity appears.

COMPOUND	SOLUBILITY	DIFFERENCE, M TO SO_4
Li_2SO_4	35.5	82.0
Na_2SO_4	19.6	50.0
K_2SO_4	*7.35*	*17.8*
Rb_2SO_4	36.4	75.0
Cs_2SO_4	167.1	169.6

Here, as the masses of the radicles approach each other, the solubility is lowered. The rule, however, as I have already indicated, is not universal. Solubility is affected by various conditions, such as hydrolysis, the formation of hydrates, etc.; but in general it seems as if a stable compound is less easily dissociated into ions than a comparatively unstable substance, and therefore, dissolves less freely. This subject is one which deserves careful investigation. The agreements shown are something more than mere coincidences.

If we study the occurrence of compounds in the mineral kingdom, we shall find many illustrations of the influence of mass equilibrium. Among the oxides, corundum is noted for its stability and inertness towards solvents, and in it aluminum and oxygen are combined in the ratio 54 to 48. Quartz, 28: 32, is also remarkably stable. Among sulfides, pyrite, with the ratio 56 to 64, is characteristic, and the fluoride, fluorspar, 40 to 38, is equally so. The fluorides of strontium and barium are as yet unknown as natural minerals, and these metals combine preferably to form sulfates in which the ratios of metal to SO_4 are simpler. Of the three fluorides, moreover, that of calcium is the least soluble, while calcium sulfate dissolves in water quite perceptibly.

When silica and alumina are combined magmatically, that is in dry fusion, only one silicate, sillimanite, Al_2SiO_5, is formed. This is the one compound, among the several which are theoretically probable, in which the ratio Al to Si + O is the simplest, 54 to 108 or 1 to 2. The silicates which contain aluminum with other metals are too complex in their ratios to admit of accurate comparison; but it is noteworthy that the relatively simple anorthite, nephelite and leucite are easily crystallized from fusion, while the more complicated albite and orthoclase are not so readily synthesized.

There is one more general relation in the mineral kingdom which is most suggestive. The elements of low atomic weight, exclusive of the halogens, are chiefly found as oxidized compounds. Sulfides appear first with calcium, as the mineral oldhamite, found only in meteorites. Sulfides of vanadium and manganese are rare, but from iron upwards they are abundant. Selenium and tellurium are chiefly combined with elements of high atomic weight, and their few oxidized compounds are merely the products of secondary alterations. Arsenic and antimony, in their primary minerals, also seek companions in the higher portions of the atomic weight scale, that is, from iron upwards. Heavy atoms seem to choose heavy partners, altho the rule is by no means universal.

To sum up: Chemical stability is favored by various conditions, but equality or approximate equality between the combining masses is one of them. This is clearly an important condition of stability, but it may be modified by any of the others. In many instances the effect of mass equilibrium is conspicuous and cannot be disregarded. The molecules of the diatomic elements, H_2, O_2, Cl_2, N_2, etc., in which two equal masses are combined, may be regarded as typical stable compounds.

BOTANY.—*Clastotypes, clonotypes and spermotypes, means for multiplying botanical type specimens.* WALTER T. SWINGLE, Bureau of Plant Industry.

In a recent number of this Journal I called attention to the possibility of multiplying type material by the use of merotypes,[1] i. e., additional herbarium specimens collected from the plant that furnished the original type specimen.

In case of the types which now exist in herbaria one cannot usually decide with certainty from what individual plant they were taken, even in the case of recently described species. It is often possible, however, to distribute to other herbaria fragments of existing types and these, even if very small, often have a high value. Such parts of types may be called clastotypes.[2]

If a photograph be taken of the type specimen before any fragments are detached, it is easy to mark on a photographic print the location of the clastotype cut away. A print so marked and preserved with the type serves to indicate its original condition, while one sent with the clastotype shows its postion on the type specimen.

So valuable are types pecimens that every portion no matter how small should be preserved. If a fragment is boiled and studied it should afterwards be added to the alcoholic collection; if examined under the microscope a permanent mount should be made. Both the alcoholic specimens and the microscopic

[1] Swingle, Walter T. Merotypes as a means of multiplying botanical types. This Journal **2**: 220–222, no. 9, May 4, 1912.

[2] Clastotype (κλαστός broken; τύπος type). A part or fragment of the type specimen of a species.

mounts should be kept in some easily accessible place, preferably in the herbarium itself, and a reference to them should be made on the sheet to which the type specimen is attached.

Frequently the same type specimen is studied by many botanists, each of whom removes a fresh portion to soak up in boiling water. If the first fragment removed for study were mounted in permanent form and properly indexed, it would often suffice for the observations of subsequent students and thus further unnecessary mutilation of the type specimen would be avoided.

Besides making merotypes and clastotypes there are other ways in which one may add to authentic type specimens.

Cuttings or buds taken from the plant that furnished the type specimen can be indefinitely multiplied by vegetative methods. Specimens cut from such plants may be called *clonotypes*.[3] They are usually very similar to merotypes but of course are subject to greater variation, since plants propagated by clones are often exposed to widely differing conditions of climate and soil, to say nothing of the profound effects produced by the different stocks upon which they may be grafted. Then, too, there are occasional bud variations or mutations in such vegatatively propagated plants.

Many plants that cannot be grafted or propagated from cuttings can nevertheless be made to yield clonotypes; for example, herbaceous perennials that propagate vegetatively by rhizomes, offshoots, or tubercules, as well as monocotyledons that reproduce by means of bulbs or bulbils.

Still another method of multiplying typical material is the sowing of seeds collected from the individual plant that furnished the type specimen. Specimens cut from the seedlings may be called spermotypes.[4] Of course the plants grown from seeds of the individual that yielded the type specimen are still more liable to vary than are vegetatively propagated cuttings or buds. Not only

[3] Clonotype (κλών, a young shoot, a twig; τύπος, type). A specimen taken from a vegetatively propagated part of the individual plant from which the type specimen was obtained.

[4] Spermotype (σπέρμα, ατος seed; τύπος type). A specimen taken from a representative plant grown from seed of the type plant.

are young seedlings more subject to new-place effects because of exposure to unusual environmental conditions, but there is also a much more serous liability to variation thru pollination of the flowers from some other species resulting in hybrid offspring. Nevertheless spermotypes frequently, in fact usually, do reproduce the parent plant almost identically and if properly compared with the type by a competent botanist yield type material of great value. An unchecked spermotype has, of course, little value. One great advantage of spermotypes is that they can be secured from the seedlings of short-lived plants which could not yield many merotypes and few or no clonotypes.

A little attention by collectors in securing seed from plants likely to become the types of new species will in many cases enable representative spermotypes of new species to be distributed in large numbers.

What with clastotypes taken from the type itself, clonotypes from vegetatively propagated parts of the type plant, and spermotypes from seedlings of it, there is certainly a possibility of distributing authentic material much more widely than has been customary in the past.

BOTANY.—*Phototypes, a means for wide distribution of type material.* MAUDE KELLERMAN, Bureau of Plant Industry. Communicated by Walter T. Swingle.

Altho the use of the camera in a museum by the visiting botanist is not a new thing the value of photography in herbarium work has not as yet been adequately realized.

Even very full notes cannot compare in value to actual photographic reproductions of the specimens themselves. The point of view of monographers changes with increasing knowledge and a character regarded as of little or no importance and hence neglected at the time notes are made may come to be considered of paramount importance later on. The camera, however, records with unfailing accuracy and without prejudice all the visible characters.

Photographs of type specimens are, of course, of the greatest

value. Indeed the importance of such a photograph is sufficient to warrant giving it a special name, *phototype*.[1]

It would be desirable for the larger herbaria to maintain a collection of phototypes in connection with that of the types themselves. The use of phototypes would enable a small herbarium to have a complete collection of the type material of those groups of which it makes a specialty.

Phototypes would be valuable for exchange and once widely distributed would cause type collections to become better known and more generally used.

The student would often find it of great convenience to be able to consult phototypes of the group he is studying when it is impossible for him to visit the various herbaria containing the type specimens themselves; these of course, should never by sent out as loans.

Where type specimens are kept separately in fireproof cases, preferably mounted in type boxes,[2] phototypes may take the place of these specimens themselves in the regular herbarium.

The prints should conform as far as possible to the size of the standard herbarium sheet. Bromide enlargements can be made from small negatives or photostat prints (11½ x 15 inches) can be made directly on sensitized paper without the intervention of a negative.

In connection with clastotypes[3] the phototype becomes important in indicating the exact location of the former on the type specimen. Phototypes of the more important parts of types and of clastotypes taken exactly natural size are very convenient and finer details of structure can be shown with a magnification of a few diameters.

When the type specimen is taken from a well-known and easily located tree it is often possible to identify the type plant with

[1] The word in this shorter form is used in preference to the cumbrous photographotype.

[2] Kellerman, Maude. A method of preserving type specimens. This Journal, **2**: 222–223, no. 9, May 4, 1912.

[3] Swingle, Walter T. Clastotypes, clonotypes and spermotypes, means of increasing type material. This Journal, **2**: 344–346, no. 14, Aug. 19, 1912.

certainty and sometimes photographs of it taken before the type specimen was collected may be in existence. Such anticipatory phototypes may be of great interest.

The highest value from a botanical standpoint must be given to synchronous phototypes taken of the fresh type specimens before they have been dried or placed in preserving fluid. If another photograph be taken at the same time showing the exact position on the type plant of the particular branch selected as the type specimen, the photographic record attains an even greater degree of perfection.

The more usual case, however, is that of the photograph taken from the dried type specimen as it exists in the herbarium. Such a subsequent phototype tho giving less information as to the nature of the species it represents than does a synchronous phototype taken in the field, has nevertheless one important advantage in that it shows the original label, thereby preventing any possible error or confusion.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

MINERALOGY.—*Mineralogical notes, Series 2.* WALDEMAR T. SCHALLER. Bulletin U. S. Geological Survey, No. 509. 1912. Pp. 115, plate and sections.

The papers included in this bulletin are as follows: *A study of the rutile group; Barbierite, monoclinic soda feldspar; Crystallized turquoise from Virginia; Crystallized variscite from Utah; Hinsdalite from Colorado; The alunite-beudantite group; Some minerals from Beaver County, Utah; Note on minerals from gabbro of Waimea Canyon, Hawaii; Cuprodescloizite from California; Mineralogy of the French phosphorites; The probable identity of podolite with dahlite; The composition of the phosphorite minerals; Natramblygonite from Colorado; The properties of mosesite; Thaumasite from Beaver County, Utah; The identity of stelznerite with antlerite.* W. T. S.

GEOLOGY.—*Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts.* F. H. MOFFIT. Bulletin U. S. Geological Survey No. 498. Pp. 82, with maps, views, and sections.

The headwater regions of the Gulkana and Susitna rivers include a high mountainous belt on the north, constituting a part of the Alaska Range and the northern margin of the Copper River basin. Between the provinces is a belt of low foot-hills rising above the plateau level, and paralleling the main range. Except in the high mountains, the rivers occupy broad alluvium-filled valleys. The region has been intensely glaciated in recent times, and the remnants of the former ice sheet are found in the several large glaciers found in the high range on the north.

The Birch Creek schists (pre-Ordovician?), the oldest rocks, occur in the northeastern part of the area and are separated by a fault from a series of quartzite tuffs and limestones lying to the south. The limestones carry Carboniferous (Mississippian?) fossils. A series of greenstones and schists occurring in the southernmost belt of foot-hills are assigned to pre-Carboniferous age. The Mesozoic is represented by basaltic lava flows and tuffs, with some shale (Triassic?), limestones (Triassic), by slate, tuffs, arkoses, etc. (Triassic), locally highly metamorphosed, and by very extensive intrusions of diorite (Jurassic?). There are also some areas of shales, with coal-beds, conglomerate and gravels, assigned to the Kenai (Upper Eocene). The Quaternary is represented by the high gravels, sands, and silts which make up the plateau, and by terrace deposits, both assigned to the Pleistocene, and by the alluvium of the present water courses. All of these rocks strike approximately east and west, and the prevailing dips are to the south. Some evidence was obtained of extensive faulting.

The gold placers of the region are in part reconcentrations from the auriferous gravels of old Quaternary deposits. It appears that the bedrock source of the gold is in the altered phases of the Triassic slates, and the mineralization is probably due to the influence of the dioritic intrusions. F. H. M.

GEOLOGY.—*The New Madrid earthquake.* MYRON L. FULLER. Bulletin U. S. Geological Survey No. 494. 1912. Pp. 119, with maps, views and sections.

The succession of shocks designated collectively the New Madrid earthquake occurred in an area of the central Mississippi Valley including southeastern Missouri, northeastern Arkansas, and western Kentucky and Tennessee. Beginning December 16, 1811, and lasting more than a year, these shocks have not been surpassed or even equaled for number, continuance of disturbance, area affected, and severity by the more recent and better-known earthquakes at Charleston and San Francisco. The earthquakes began a little after 2 a.m. on December 16 and continued the next day at short intervals, but gradually diminished in intensity. They occurred at long intervals until January 23, when there was another shock, similar in intensity and destructiveness to the first. This shock was followed by about two weeks of quiescence, but on February 7 there were several alarming and destructive shocks, the last equaling or surpassing any previous disturbance, and for several days the earth was in a nearly constant tremor.

For fully a year from this date small shocks occurred at intervals of a fews days, but as there were no other destructive shocks the people gradually became accustomed to the vibrations and gave little or no further attention to them.

There is geologic evidence of earthquakes in this region long antedating that of 1811. Cracks as large as any of those caused by the last great disturbance have been seen covered by trees fully 200 years old. Nor is the action apparently altogether recent, for post-Lafayette but pre-Iowan faults (antedating the deposition of the loess), and apparently being either a cause or accompaniment of earthquakes, have been observed in Crowley Ridge, and Glenn has described sandstone dikes filling old earthquake cracks in the Porters Creek formation of the Eocene Tertiary.

The area affected by the New Madrid earthquake may be subdivided into an area of marked earth disturbances, an area of slight earth disturbances, and an area of tremors only. The total area characterized by disturbances of the first type is from 30,000 to 50,000 square miles; of the second type, of over a million square miles.

Godfrey Le Sieur, who witnessed the shock, described it as follows: "The earth was observed to roll in waves a few feet high, with visible depressions between them. By and by these swells burst, throwing up large volumes of water, sand, and coal." The movement in the area of principal disturbance was from the southwest.

The tectonic effects of the earthquake were fissures, faults, landslides, uplifts, domes, and depressions. There were also extrusions of gas, water, and of various rock-making materials. The general trend and shape of the affected area, taken in connection with the direction of the earth waves, points to a centrum of the original shock along a northeast-southwest line extending from a point west of New Madrid to a point a few miles north of Parkin, Ark. The centrum of the heavier subsequent shocks seems also to have been along essentially the same line. The location of the centrum of some of the later and lighter shocks may have been elsewhere. Inasmuch as the center of activity of the primary shocks is within the embayment area of the Mississippi Valley and well removed from the surrounding areas of consolidated rocks, it seems clear that the ultimate cause lies in forces operating beneath the embayment deposits. The action may be associated either with the processes of folding or warping or be incident to a depression and deepening of the basin. A. H. Brooks.

GEOLOGY.—*The Devonian and Mississippian formations of northeastern Ohio.* CHARLES S. PROSSER. Bulletin 15, Fourth Series, Geological Survey of Ohio. 1912.

This bulletin contains a description of the Devonian and Mississippian formations as followed from Rocky River Valley west of Cleveland eastward across northern Ohio into the western part of Pennsylvania. A large number of sections are described and some of the most striking outcrops or formation contacts are illustrated by half-tones.

The formations of the area described are classified as follows:

SYSTEM	SERIES	FORMATION	MEMBER
Carboniferous	Pennsylvanian...	Pottsville formation	Sharon conglomerate
	Mississippian	Royalton formation	Sharpsville sandstone
		Orangeville formation	Brecksville shale Aurora sandstone Sunbury shale
		Berea grit	
		Bedford formation	Sagamore sandstone Euclid sandstone
Devonian		Cleveland shale Chagrin formation	

In the above table the Euclid and Sagamore members are merely two sandstone lentils of the Bedford and they do not represent the thickness of the entire formation. The Sunbury shale, Aurora sandstone and Brecksville shale represent the entire thickness of the Orangeville formation, while the Sharpsville sandstone and Sharon conglomerate represent only the lower part respectively of the Royalton and Pottsville formations. The Orangeville formation of the Second Pennsylvania Survey has been adopted for the Ohio classification with the same limits that Dr. I. C. White gave it near the Ohio-Pennsylvania State line, viz., from the top of the Berea grit to the base of the Sharpsville sandstone.

The Cuyahoga terrane of Newberry in the Cuyahoga Valley, which is its typical region, may readily be divided into two formations, the lower one about 125 feet thick consisting largely of blackish shales which

is correlated with the Orangeville formation of Pennsylvania and this name is adopted for it. The upper formation of the Cuyahoga terrane consists of alternating blue sandstones and shales, the latter predominating in thickness, and this one has been named the Royalton from the outcrops in that township to the southwest of Cleveland. The disconformity between the Bedford and Berea formations is described and illustrated. This disconformity has been followed from near the Grand River in eastern Ohio west and southwest into central Ohio to the south of Columbus.

It is shown that the fauna of the Chagrin consists of Chemung species which extend as far west as the western tributaries of the Cuyahoga River, south of Cleveland. For example, in Ashtabula County, which is the northeastern one of Ohio, 29 species and varieties have been identified from the Chagrin, of which 6 are confined to the Ohio formation, leaving 23 for consideration in reference to correlation. Seventeen, or nearly 74 per cent of the above list, are confined to the Chemung formation and every one of the list occurs in the Chemung formation of either New York or Pennsylvania. Ten additional forms are either identified with a ? mark or compared with a species and these are also found in the Chemung, so that 84.5 per cent of the total Chagrin fauna of this county is found in the Chemung formation of New York and Pennsylvania. Consequently the fossiliferous portion at least of the Chagrin formation is regarded as the western continuation of the Chemung formation of New York.

The bulletin contains a chapter on correlation devoted principally to the formations of the upper Devonian and lower Mississippian. The evidence and literature relating to the line of division between the Devonian and Carboniferous systems in northern Ohio is summarized, a question that has recently become one of the most controverted points in the geology of Ohio. The final chapter is devoted to the paleontology of the Chagrin formation, in which a part of its brachiopod fauna is described and illustrated. C. S. P.

BOTANY.—*Le genre Balsamocitrus et un nouveau genre voisin, Æglopsis.* WALTER T. SWINGLE. Bull. soc. bot. de France, (1911), 58 (Mém 8d): 225–245, Figs. A–B, Pls. 1–5, (2 Mar. 1912), (in Chevalier, Aug., Novitates floræ africanæ fasc. **4**: 225–245). Reprinted in Chevalier, l.c., and separately with original pagination.

A study of the material from tropical Africa in Paris, resulted in bringing to light two additional species of *Balsamocitrus* as well as a new

monotypic genus, *Aeglopsis*. Both of these genera are hard-shelled citrous fruits related to the Indian *Aegle* [Belou] *marmelos*.

The genus *Balsamocitrus* is divided into two sections: *Eubalsamocitrus*, having a small disk and twice as many stamens as petals; and a new section, *Afraegle* having a larger, lobed disk and four times as many stamens as petals.

The type species of the genus, *B. Dawei*, Stapf, from the Budongo Forest of Uganda, belongs to the first of these sections.

The new section, *Afraegle*, is created for *B. paniculata* (Schum.) Swingle. This plant was first collected by Thonning and published by Schumacher in 1827 or 1828 as *Citrus Paniculata*. The original description of Thonning given by Schumacher is sufficient to show that the plant must be allied to *Balsamocitrus*.

There is a cotype of this species in the Jussieu herbarium in Paris which is identical with *Aegle Barteri*, Hook, and *Limonia Warneckei* Engl., as proved by comparison with the types of these latter species preserved at Kew and Berlin.

Citrus paniculata Schum., which has been a puzzle to botanists for more than a century, is therefore the oldest name for the plant in question.

The third species, *B. gabonensis*, Swingle, n. sp., cannot yet be definitely placed in either of the section given above, as its flowers are not known. The fruits, which are used as powder flasks by the natives of French Congo and Kamerun, are large ($3\frac{1}{4}$ inches in diameter), slightly pyriform, with numerous seeds.

In 1907 M. Chevalier found at Sassandra, Côte d'Ivoire, a shrub or small tree much resembling *Balsamocitrus*, but which is in reality a new genus, *Aeglopsis*. It differs from *Balsamocitrus* principally in the structure of the ovary, which is only 6-locular. The cortex of the fruit is much thinner and the cells are large and triangular, with thin walls. The leaves are simple, short-petioled, with numerous glands. This new genus is founded on *A. Chevalieri*, Swingle, n. sp., which occurs at Sassandra and at Tabu, near the eastern frontier of Liberia.

Aeglopsis has a special interest for trial as a stock for *Citrus*, since it is said to resist more or less salt in the soil.

All the species mentioned above are figured in the two text cuts and four plates. A half tone plate is also given of *Aegle glutinosa* (Blanco) Merrill, a related plant from the Philippines.

MAUDE KELLERMAN.

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This volume comprises the following articles: *The auriferous gravels of the Trinity River basin, Cal.*, J. S. DILLER; *The economic geology of Carson camp, Hinsdale County, Colo.*, E. S. LARSEN; *Geology and mineralization of the upper St. Joe River basin, Idaho*, J. T. PARDEE; *Gold-bearing ground moraine in northwestern Montana*, F. C. SCHRADER; *Geologic relation of ore deposits in the Elkhorn Mountains, Mont.*, R. W. STONE; *Notes on the economic geology of the Ramsey, Talapoosa, and White Horse mining districts, in Lyon and Washoe counties, Nev.*, J. M. HILL; *The ore deposits near Pinos Altos, N. Mex.*, SIDNEY PAIGE; *Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.*, SIDNEY PAIGE; *Preliminary report on the mineral deposits of Ducktown, Tenn.*, W. H. EMMONS and F. B. LANEY; *Notes on lead and copper deposits in the Bear River Range, Idaho and Utah*, R. W. RICHARDS; *Lead and zinc deposits in the Metaline mining district, northeastern Washington*, HOWLAND BANCROFT; *The arsenic deposits at Brinton, Va.*, F. L. HESS; *Iron ores in the Montevallo-Columbiana region, Alabama*, CHARLES BUTTS; *Variegated marble southeast of Calera, Shelby County, Ala.*, CHARLES BUTTS; *Supplementary notes on the commercial granites of Massachusetts*, T. N. DALE; *Clay near Calhan, El Paso, County Colo.*, G. B. RICHARDSON; *Clay resources of the Murphysboro quadrangle, Illinois*, E. W. SHAW; *Notes on some clays from Texas*, ALEXANDER DEUSSEN; *Gypsum deposits in Eagle County, Colo.*, E. F. BURCHARD; *Preliminary report on a portion of the Idaho phosphate reserve*, R. W. RICHARDS and G. R. MANSFIELD; *Rock phosphate near Melrose, Mont.*, H. S. GALE; *A reconnaissance of the phosphate deposits in western Wyoming*, ELIOT BLACKWELDER; *Paint shales of Pennsylvania*, B. L. MILLER; *Sulphur deposits, near Soda Springs, Idaho*, R. W. RICHARDS and J. H. BRIDGES; *The types, modes of occurrence, and important deposits of asbestos in the United States*, J. S. DILLER; *Dolomite for flux in the vicinity of Montevallo, Shelby County, Ala.*, CHARLES BUTTS; *Graphite near Dillon, Mont.*, A. N. WINCHELL; *Fluorspar near Deming, N. Mex.*, N. H. DARTON and E. F. BURCHARD.

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AGRICULTURE.—*Soil surveys* (Advance sheets—Field operations of the Bureau of Soils, 1909–1910) as follows:

Ellis County, Texas. FRANK BENNETT, R. T. AVON BURKE, and CLARENCE LOUNSBURY. Pp. 34. Map.

Panhandle Region Texas. (Reconnaissance.) WILLIAM T. CARTER, JR., and Party. Pp. 59. Pls. 6. Map.
Point Pleasant area, W. Va. W. J. LATIMER and CHARLES N. MOONEY. Pp. 50. 2 Maps.
Marinette County, Wis. (Reconnaissance.) S. WEIDMAN, Wisconsin Geological and Natural History Survey, and Percy O. WOOD, U. S. Department of Agriculture. Pp. 39. Pls. 4. Map.

HYDROLOGY.—*Surface water supply of the United States, 1909.* Part I, *North Atlantic Coast.* H. K. BARROWS, C. C. COVERT, and R. H. BOLSTER. Water-Supply Paper U. S. Geological Survey No. 261. Pp. 309, with views. Part III, *Ohio River basin, 1909.* A. H. HORTON, M. R. HALL, and R. H. BOLSTER. No. 263. Pp. 192. Pls. 6. 1911. Part V, *Hudson Bay and upper Mississippi River basins, 1909.* ROBERT FOLLANSBEE, A. H. HORTON, and R. H. BOLSTER. No. 265. Pp. 231. Pls. 5. 1911. Part VI, *Missouri River basin.* W. A. LAMB, W. B. FREEMAN, and F. F. HENSHAW. No. 266. Pp. 291. Pls. 5. Part IX, *Colorado River basin.* W. B. FREEMAN and R. H. BOLSTER. No. 269. Pp. 247. Pls. 9. Part XI, *California.* W. B. CLAPP and F. F. HENSHAW. No. 271. Pp. 256. Pls. 6. 1911. Part VIII, *Western Gulf of Mexico.* W. B. FREEMAN and J. G. MATHERS. No. 288. Pp. 149. Pls. 3. 1911.

ENGINEERING.—*Results of spirit leveling in Alabama, Georgia, North Carolina, South Carolina, and Tennessee, 1896, to 1909.* R. B. MARSHALL. Bulletin U. S. Geological Survey No. 441. Pp. 145. 1911. *Retracement of the boundary line between Idaho and Washington from junction of Snake and Clearwater rivers northward to the International Boundary.* R. B. MARSHALL. No. 466. Pp. 39, map and sections. 1911. *Results of spirit leveling in North Dakota, 1897 to 1910.* R. B. MARSHALL. No. 469. Pp. 22. 1911. *Results of spirit leveling in Kansas and Nebraska, 1896 to 1909.* R. B. MARSHALL. No. 473. Pp. 42. 1911. *Results of spirit leveling in California, 1907 to 1910.* R. B. MARSHALL. No. 481. Pp. 115. *Results of spirit leveling in Colorado, 1896 to 1910.* R. B. MARSHALL. No. 486. Pp. 107. *Results of spirit leveling in Idaho, 1896 to 1909.* R. B. MARSHALL 487. Pp. 43. 1911. *Results of spirit leveling in Montana, 1896 to 1910.* R. B. MARSHALL. No. 482. Pp. 154. 1911. *Results of spirit leveling in Nevada, 1897 to 1909.* R. B. MARSHALL. No. 488 1911. *Results of spirit leveling in Illinois, 1909 and 1910.* R. B. MARSHALL. No. 493. Pp. 109. 1911.

LAW.—*Mining laws of Australia and New Zealand.* A. C. VEATCH. Preface by Walter L. Fisher, Secretary of the Interior. Bulletin U. S. Geological Survey No. 505. Pp. 180. 1911.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY OF WASHINGTON

The 254th meeting was held in the Cosmos Club March 13, 1912, President Stanton being in the chair. The following informal communications were presented:

Mr. David White brought up the question of the formation of limestone near tide level thru the agency of calcareous algae and called attention to the very important as well as striking data on the subject published in the 18th part of the "Siboga-Expeditie," and to the work of Rothpletz and other paleontologists on limestones of various ages in Europe. Expressing the opinion that many of the limestones of the American coalfields were formed very close to tide level and under climatic conditions shown by the associated land plants to be favorable for great development of coralline algae, the speaker hoped that this branch of paleontology, almost untouched in America, might engage the interest of some of our young paleontologists.

Mr. K. D. Burling described the reëxamination by Mr. J. A. Allan and himself of the Mount Bosworth (British Columbia) section described by Dr. Charles D. Walcott in 1908, in an attempt to determine the position in that section of a series of 2500 feet of Cambrian shales and limestones measured by Mr. Allan in the Ice River Region, and announced the finding of typical Upper Cambrian (Sherbrooke) fossils in the "Ordovician" beds forming the top of the exposed section, a discovery which enabled them to place the Ice River beds in the interval between the Sherbrooke and the true Ordovician.

Mr. F. E. Matthes briefly called attention to the introduction by French topographers of two new terms, "topology" and "topometry," expressing concepts related to that of "topography," but different from it. He gave the definitions, as laid down by Berthaut, and discussed the desirability of the wider adoption of these terms, and the value of the more precise differentiation between the respective concepts which would ensue.

REGULAR PROGRAM

The development of a typical bolson in the Southwest: O. E. MEINZER. The Spanish term "bolson," is used to designate constructional detritus plains occupying structural troughs in arid regions. A good example of a plain of this type is afforded by Sulphur Springs Valley in southeastern Arizona. The northern part of this valley is a completely closed bol-

son, one that holds the surface water, with its mechanical sediments, and the underground water, with its dissolved solids. This closed basin is, on the whole, being aggraded but is suffering stream erosion (1) on the upper parts of the slopes, and (2) near the playa. The high-level erosion results in part from the normal development of the gradational cycle, the large canyons having been cut deeper than the smaller ones, and all of them having been progressingly lowered. The basin held an ancient lake of 120 square miles with 30 miles of beach ridge. Inside the ancient strand is a playa covering 51 square miles. Northeast of the playa is a dune area produced by southwest storm winds. Search for ancient shore features in any bolson in this region should begin on the southwest side of the playa, where such features are not covered by wind deposits.

A completely closed bolson has two surfaces: a débris surface and an underground-water surface. The base-levels of the two generally coincide. The débris base-level is gradually raised by débris from the mountains. Since the water supply is much larger than the débris supply the water base-level is kept up to the débris base-level, and were it not for evaporation the water-level would be raised indefinitely. As long as the water-level does not rise above the playa the débris surface is a self-developed unit, but when it rises above the playa, the submerged part of the débris surface is placed under new conditions and the part remaining above water adjusts itself to the lake-level, which is the new base-level accidentally imposed upon it. In Sulphur Springs Valley the débris surface has not yet readjusted itself since the disappearance of the Pleistocene lake, as is shown by the erosion near the playa.

In a completely closed bolson the soluble minerals are concentrated in the central area of evaporation, and as the valley is aggraded they are carried upward and reconcentrated at the surface. The very shallow waters in the area of evaporation are generally more highly mineralized than the deeper waters and the waters below the slopes. The waters below the slopes adjacent to igneous mountains contain less mineral matter than those below the slopes adjacent to mountains of sedimentary rock. Also the mineral matter is of a different kind, the soluble material in the soil derived from the igneous mountains being largely sodium carbonate.

The fill of the Gila Valley has been eroded and this erosion has extended to Sulphur Springs Valley, capturing several of its arroyos. Hence this bolson, with its delicate gradational adjustments, is an ephemeral feature.

Certain deposits in Sulphur Springs and adjacent valleys that indicate deposition in lakes or seas lie beneath the stream deposits and represent an older submergence than do the beaches.

The magmatic sulfide ore body at Elkhorn, Montana: ADOLPH KNOPF. The Golden Curry Mine at Elkhorn, Montana, has produced 50,000 tons of iron ore carrying $4 a ton in gold, which has been used mainly as a flux for the lead smelters. One of the sources of this iron ore was a lens of sulfide ore occurring in quartz monzonite 250 feet from the contact

with metamorphosed limestone. This ore body is elliptical in plan; it is 100 feet long, 20 feet wide, and has been stoped upward to a height of 10 or 12 feet. From it were extracted 2000 tons of ore carrying $4 in gold, 35 per cent excess iron, and 2 per cent in copper.

The ore consists of a mixture of pyrrhotite and chalcopyrite in a gangue of augite. Surrounding the sulfide mass and grading into it is a body of dark heavy rock of fresh appearance and of even-grained granitic texture, which proves upon microscopic examination to be a pyrrhotite augite diorite. This rock in turn grades laterally outward into quartz monzonite composed of plagioclase, orthoclase, quartz, biotite, and hornblende, which is the normal country rock. The facts pointing to the primary igneous origin of the sulfides are the following: (1) The lack of evidences of hydrothermal alteration in the ore and wall rocks; (2) the textural relation of the sulfides to the augite as shown by the tendency of the pyroxene to develop idiomorphic boundaries against the sulfides; and (3) the marked differentiation that has taken place in the magma concurrently with the segregation of the sulfides, expressed mineralogically by the decrease of the othoclase, quartz, and biotite, and the concurrent increase of the ferromagnesian minerals, as the ore body is approached.

The mineral composition of the primary ore as a factor determining the vertical extent of the secondary sulfide zones: W. H. EMMONS. It is generally supposed that waters descending from the surface in sulfide ores rapidly lose acidity. Two samples taken from the same column of water in a shaft in a body of pyrrhotite ore at Ducktown, Tennessee, indicate a decrease of acidity of more than one-half at a depth only 37 feet below the top of the body of standing water.

At Ducktown, Tennessee, and in many other copper deposits containing abundant pyrrhotite, the chalcocite zones are restricted to a few feet in vertical extent, whereas they may be hundreds of feet in vertical extent in pyritic ores containing little or no pyrrhotite. With a view to ascertaining the effect of dilute acid sulfate waters on several sulfides Dr. R. C. Wells carried out the following experiments. Equal volumes of ground sulfides similarly sized were treated separately with dilute ferric sulfate and acid sulfate solutions, and also with acid sulfate solutions about 1/20 normal. The rate of attack with acid sulfate was in the following order: Pyrrhotite, sphalerite, galena, chalcopyrite and pyrite. The action with pyrrhotite was about 25 times as rapid as with sphalerite and with sphalerite at least 4 times as rapid as with pyrite or chalcopyrite. The generation of hydrogen sulfide was proved in the action on pyrrhotite, sphalerite and galena.

Since hydrogen sulfide precipitates copper, gold, silver and some other metals from acid solutions, it would not be supposed that these metals would be carried far below the zone where hydrogen sulfide was being generated by the action of acid on sulfides. They could probably be carried to greater depths in ore composed of pyrite and chalcopyrite without pyrrhotite or sphalerite than in sphalerite ores, and to greater depths in sphaleritic ores containing no pyrrhotite than in ores contain-

ing abundant pyrrhotite. A statistical review of a number of ore deposits classified with respect to the mineral composition of the primary ore appears to lend some support to this hypothesis, since chalcocite zones in ores containing abundant pyrrhotite are generally limited vertically while those containing sphalerite pyrite, and chalcopyrite extend to greater depths.

The 255th meeting was held in the Cosmos Club March 27, 1912, with President Stanton in the chair.

REGULAR PROGRAM

An occurrence of emeralds in North Carolina: D. B. STERRETT. Emeralds are found in several types of deposits. In Columbia they occur in calcite veins in bituminous limestone; in Upper Egypt and in the Ural Mountains, in dark mica schist interfoliated with talc schist; in the Salzburg Alps, in a greenish-brown mica schist interbedded with chlorite and hornblende schist; in Maine, Connecticut, and on Crabtree Mountain, Mitchell County, North Carolina, in pegmatite; at Hiddenite in Alexander County, North Carolina in cavities in veins cutting biotite gneiss, associated with quartz, calcite, dolomite, muscovite, rutile, black tourmaline, pyrite, monazite, and hiddenite.

At a new locality in Cleveland County, North Carolina, $4\frac{3}{4}$ miles S.30°W. of Shelby, emeralds occur in pegmatite cutting hornblende hypersthenite and olivine gabbro. Some of the hypersthenite contains olivine and grades into gabbro. The two rocks are probably genetically related. Both have been intruded and surrounded by biotite granite. The granite has acted on the basic rock both absorbing and altering the composition of part to less basic variety. Pegmatite, probably genetically associated with the granite, has filled fissures in the basic rocks. In one of these pegmatites emeralds have been found. It is suggested that the agencies which formed the pegmatite contained the necessary elements of the formation of beryl. The absorption of some of the basic rock by the granite magma supplied the oxide of chromium necessary to impart an emerald green color to the beryl. Analyses by Dr. R. C. Wells, of the Geological Survey, showed the presence of 0.16 per cent Cr_2O_3 in the hornblende hypersthenite and of 0.17 per cent in the olivine gabbro. This is practically the same percentage of oxide of chromium contained in emerald. Beryl found in other pegmatites inclosed in granite and mica gneiss in this region are pale aquamarine green, yellowish, or white.

Some emeralds of fine color have been found at the new locality. The best one was found on the surface in a cotton field. It is about half of a crystal, split parallel with its length, and measures about 1 by $\frac{3}{4}$ by $\frac{1}{2}$ inch. The color is a fine deep green. About a quart of emeralds have been found in all and the color and quality of these are about equal to the average emeralds from Columbia. The best gem so far cut from this North Carolina locality weighs 0.83 carats and has been valued at

$200 per carat. Other crystals that have not yet been cut will probably yield equally fine stones.

The salt and gypsum deposits of southwestern Virginia: GEORGE W. STOSE. The deposits described are in the valley of North Holston River in the vicinity of Saltville and are associated with a soft shaly formation (Pulaski) of upper Mississippian age, 1000 feet thick. This formation overlies the Price sandstone, which represents the Pocono of Pennsylvania, and underlies the Newman limestone, which represents the Greenbrier of that region.

The gypsum was formerly considered to have been derived from limestone by the action of sulfuric acid solutions derived from oxidizing pyrite in the associated black shales, but more recently has been described by Eckel as sedimentary in origin. The fact that the deposits are found only close to a great fault which overthrusts Cambrian dolomite from the southeast upon the Pulaski formation, leads to the present conclusion that the thick deposits of both gypsum and salt are due to concentration in the Pulaski formation, by meteoric waters circulating along the fault, of minerals originally disseminated in the same formation by sedimentation under salt-pan conditions. Further evidence in support of this view was presented.

Classification of metalliferous mineral lands: R. W. STONE. A great part of the work of the Metalliferous Board of the Land Classification Board of the Geological Survey has been the classification of land in the Northern Pacific Railroad grant. This grant made by Congress to the Northern Pacific in July, 1864, to aid in the construction of a railroad and telegraph line from Lake Superior to Puget Sound was a gift of 20 alternate square miles of non-mineral land on each side of the right of way for each mile of road in the territories, and 10 alternate square miles in the States. Two in lieu strips, each 10 miles wide, granted subsequently, made in the territories a strip of land 120 miles wide in which the railroad had a claim to all odd-numbered sections of non-mineral land. The first formal classification of these lands was provided for by Act of Congress, February 26, 1895, the work to be done by three commissioners in each of four land districts in Montana and Idaho. Many of the classifications made by these commissioners were protested and vacated as fraudulent. June 25, 1910, Congress made an appropriation to complete the examination and classification of lands within the Northern Pacific grant. This work was begun in July 1910 by Messrs. Calkins, McDonald, Pardee, and E. E. Smith in Idaho and Stone in Montana, all under the supervision of Mr. H. S. Gale, and was continued in 1911.

In the public domain and in Indian Reservations the classification as mineral or non-mineral is based on a consideration of relative values, agriculture, grazing, and timber possibilities being balanced against the probability of paying mineral deposits. In the Northern Pacific grant, "Is the land mineral or non-mineral?" is the whole question. The main point of contention between the government and the railroad is the interpretation of the law as to what constitutes evidence of mineral land.

The 256th meeting was held in the Cosmos Club April 10, 1912, President Stanton in the chair.

REGULAR PROGRAM

Discussion of the relation of forestation to streams and erosion: Led by Prof. Willis L. Moore, Dr. W J McGee, Dr. F. B. Laney.

The following members and guests also took part in the discussion: C. A. Davis, W. L. Hall, A. C. Spencer and G. O. Smith.

ROBERT ANDERSON,
RALPH W. RICHARDS,
Secretaries.

WATERMARK